the plan to public notice and general adoption. From their report we select a few details which, hitherto, we believe, have not appeared in English.

When water is converted into ice an increase in bulk suddenly takes place with such amazing force that it appears to be almost irresistible. This is the force which cracks our water-bottles and ewers; splits asunder the trees of our forests; and destroys some of the stones of our buildings. But the action of frost upon stone is very gradual; it is confined to the surface, and when we see a layer of stone separated from the rock or the building, we see the result of the action of the frost during several successive winters, whereby the fragment is gradually thrust out of its perpendicular position, and at length falls. This natural process is repeated in our buildings: we rarely see squared stones split into large fragments by the action of frost except there be a cavity of some considerable size, in which a quantity of water can be collected. The usual action of the frost is at the surface, which is destroyed by the chipping off small fragments in consequence of the adhesion of the materials of the stone being partially destroyed.

All stones absorb water in greater or less quantities, and there is no rock that does not contain some humidity. The great difference between stones which is now to be considered is in their power of resisting frost. Stones of the same kind, nay, stones from different parts of the same quarry, are acted upon very differently by frost; for, while one stone soon begins to shew the destructive effects of its action, another remains uninjured during many centuries. It will, therefore, be convenient to call those stones, of whatever kind, which withstand the action of frost, *resistant*, and those which yield to its action, *non-resistant*.

M. Brard's first idea, in order to test these resistant properties in building-stones, was to saturate the stone with water, and then expose it to cold artificially produced; but this was found to be impracticable on a large scale, and the freezing mixtures and other means of producing cold were liable to act chemically upon the stone, and thus produce other effects than those of cold.

M. Brard was then led to compare water with those numerous solutions of the chemist, which, under certain modes of treatment, crystallize. The expansive force of salts in crystallising is very great, and he saw no reason why water should not be regarded as a crystalline salt similar in its nature to those saline bodies which effloresce at the surfaces of stones, and in time destroy them and even reduce them to powder.

He therefore tried, in a very large number of experiments, the action upon building-stones of solutions of nitre, of common salt, of Epsom salts, of carbonate and sulphate of soda, of alum and of sulphate of iron, and found that the stones cracked and chipped, and in many cases behaved precisely in the same way as when under the influence of freezing water. In the course of these trials, sulphate of soda (Glauber's salts) was found to be the most energetic and active, and to be the best exponent of the action of freezing water.

In order, therefore, to determine promptly if a stone be resistant or non-resistant, the following process was adopted. A saturated solution of sulphate of soda was made in cold water; the solution being put into a convenient vessel, the stone was immersed, and the solution boiled during half an hour: the stone was then taken out, and placed in a plate containing a little of the solution. It was then left in a cool apartment, in order to facilitate the efflorescence of the salt with which the stone was now impregnated. At the end of about twenty-four hours the stone was covered with a snowy efflorescence, and the liquid had disappeared either by evaporation or by absorption. The stone was then sprinkled gently with cold water until all the saline particles disappeared from the surface. After this first washing the surfaces of the stone were covered with detached grains, scales, and angular fragments, and the stone being one that was easily attacked by frost, the splitting of the surfaces was very marked. But the experiment was not yet terminated: the efflorescence was allowed to form, and the washing was repeated many times during five or six days, at the end of which time the bad qualities of the stone became fully established. The stone was finally washed in pure water; all the detached parts were collected, and by these the ultimate action of the frost upon the stone was estimated.

The behaviour of various non-resistant stones under this process was remarkable. Some were found to have deteriorated in the course of the third day; others to have entirely fallen to pieces; those of which the power of resistance was somewhat greater, held out till the fifth or sixth day; but few stones, except the hard granites, compact limestones, and white marbles, were able to stand the trial during thirty consecutive days. For all useful purposes, however, eight days suffice to test the resistant qualities of any building-stone.

The explanation of this process is very easy. The boiling solution dilates the stone and penetrates it to a certain depth, nearly in the same way that rain-water by long-continued action introduces itself into stones exposed to the severity of our changeable climate. Pure water when frozen occupies a greater bulk than when fluid, and the pores or cellules of the stone not being able to accommodate themselves to the increased bulk of the water, great pressure is exerted between and among them, whereby a portion of the water is driven to the surface, and in doing so rends and detaches small portions of the stone. The same action takes place with the saline solution; it is introduced into the stone in a fluid state, from which passing into the solid it occupies a greater bulk, and a portion of it appears at the surface. The repeated washings have no other object than to allow the salt to exert its greatest amount of destructive action upon the stone. There is a striking analogy between the effect of congealed water and that of the efflorescence of salts, in the disintegration of non-resistant stones; namely, that pure water acts on the stones destructively only in a state of snowy efflorescence, which evidently proceeds from the interior to the exterior like the saline efflorescence; whilst water at the surface of the stones may freeze into hard ice without injuring them, just in the same way as the salts, which may crystallize upon stones without exerting any injurious action.

The experience of several engineers, extending as it does over several years, fully proves, of a large variety of stones whose qualities were well known, that the action of M. Brard's process and that of the long-continued frost exactly coincide.

It is not the least interesting part of the inquiry to know that this process may be applied with perfect success to ascertain the solidity and resistant power of bricks, tiles, slates, and even mortar. From a mass of minute detail, we will select a few general results.

During one winter season M. Vicat composed seventy-five varieties of mortar, the difference between any two consisting in the proportion of sand and the method of slaking the lime. In the following June these mortars were exposed to the disintegrating process. Most of them were attacked in twenty-four hours; almost all of them in forty-eight hours; and all except two in three days. This gentleman also found that a mortar made ten years previously, of one hundred parts lime which had been left exposed to the air, under cover, during the whole year, and then mixed up into a paste with fifty parts of common sand, withstood the trial admirably during seventeen days, while the best stones of the neighbourhood speedily gave way. In this case the solution was saturated while hot, which is so powerful in its effects that stones which have resisted the action of the frost for ages, soon give way when exposed to it.

M. Vicat calculates that the effect of the sulphate of soda upon a non-resistant stone after the second day of trial equals a force somewhat greater than that exerted by a temperature of about 21 degrees Fahrenheit, on a stone saturated with water.

The action of the process upon bricks proved that, whatever their qualities in other respects, if imperfectly burnt, they are speedily acted on. The sharp edges of the brick, and then the angles, are first rounded, and finally the brick is reduced to powder. Such is precisely the action of frost often repeated. Well-baked bricks, on the contrary, retain their colour, form, and solidity by this process, as well as under the influence of frost. Ancient Roman bricks, tiles, and mortar, and hard well-baked pottery resisted the process perfectly; as did also white statuary marble of the finest quality, while common white marble was soon attacked. In Paris, portions of buildings which had been exposed to the air during twenty years without undergoing the least alteration, were submitted to this ordeal, and the experiment agreed with observation. In one extensive series of experiments on stones from different quarries of France, the action of the salt was continued for seven days, and the results noted down; it was then continued for fourteen days, and the results compared with the preceding ones; which only served to confirm the judgment first given, for those stones which were noted as of bad quality crumbled to dust or split into fragments, while those noted for their good qualities had experienced no sensible alteration.

One of the great advantages of this process is the power it gives to the architect of choosing a hard, durable stone for those parts of the building most exposed to the action of the weather, when the funds are insufficient to admit of the whole building being so constructed. Thus the cornices, the columns, and their capitals, are struck in all directions by rain, and hail, and damp air, and are consequently far more exposed to their destructive action than the flat surface of a wall, which offers but one plane to the air.

In the course of this inquiry a very curious case arose. During the erection of a church in Paris, the architect required a good durable stone for the Corinthian capitals; and many circumstances disposed him to select it from the neighbouring quarry of the Abbaye du Val. But, on seeking the opinion of two brother architects, he was surprised to find their estimations of the stone to be totally at variance, for while one declared that he had employed it with the greatest success, another said that he had seen it yield speedily to the effects of frost. On visiting the quarry it was found that two beds of stone were being worked, an upper and a lower bed; specimens of the stone were taken from each, and on submitting them to a hot saturated solution, it was ascertained almost immediately that the upper layer furnished excellent stone, while the lower one supplied that of which the architect had so much reason to complain. But it is remarkable that the stones from the two beds had precisely the same appearance in grain, colour, and texture; so much so, that when brought into the mason's yard it was impossible by ordinary tests to distinguish the good from the bad stone.

At the conclusion of the inquiry of the committee, the Royal Academy of Sciences proved the high estimation in which they held this contribution of science to the useful arts, by directing to be published the following practical directions for repeating the process, for the use of architects, builders, master-masons, land proprietors, and all persons engaged in building.

1. The specimens of stone are to be chosen from those parts of the quarry, where from certain observed differences in the colour, grain, and general appearance of the stone, its quality is doubtful.

2. The specimens are to be formed into two-inch cubes, carefully cut, so that the edges may be sharp.

3. Each stone is to be marked or numbered with Indian ink or scratched with a steel point; and, corresponding with such mark or number, a written account is to be kept as to the situation of the quarry, the exact spot whence the stone was detached, and other notes and information relating to the specimen.

4. Continue to add a quantity of sulphate of soda to rain or distilled water, until it will dissolve no more. You may be quite sure that the solution is saturated, if, after repeatedly stirring it, a little of the salt remains undissolved at the bottom of the vessel an hour or two after it has been put in.

5. This solution may be heated in almost any kind of vessel usually put on the fire, but perhaps an earthen pipkin may be most convenient. When the solution boils, put in the specimens of stone, one by one, so that all may be completely sunk in it.

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